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Impact of Bank-protection Work on *Stenopsyche marmorata* (Trichoptera) in the Middle Reaches of the Chikuma River in Central Japan

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Since a large bank-protection works project was undertaken during winter in the middle reaches of the Chikuma, the riverbed structure was drastically altered. In order to assess the short-term impact of bank-protection works on the abundance pattern of *Stenopsyche marmorata* (Trichoptera) from spring to early summer, we conducted an investigation on the capture of adults using light traps before and after construction work. The patterns of the daily capture of *S. marmorata* and the cumulative number of individuals were different before and after construction. Namely, after construction, the daily catch of adult numbers increased only slightly during the investigation periods. This suggested that the age structure of the *S. marmorata* larval population had changed in the construction area. Our data suggest that bank-protection projects impact the abundance pattern of adult caddisflies in the river ecosystem.

Key words : abundance pattern, bank-protection work, Chikuma River, caddisfly, larval age structure, *Stenopsyche marmorata*

INTRODUCTION

In Japan, almost all bank-protection projects are undertaken on rivers during winter. The size and duration of these projects vary, but most of them target a specific area of a river district in which to construct these protective works. However, their impact on the benthic macroinvertebrates living off these rivers has seldom been reported, and much remains unknown (Hurlbert, 1984; Strwart-Oaten *et al*., 1986; Brooks and Boulton, 1991; Underwood, 1992, 1994; Downes *et al*., 2002). Studies of the effects of man-made environmental disturbances on river benthic communities are important in improving our understanding of the structure of aquatic insect assemblages, and in making practical assessments of such impacts in the context of wildlife conservation (Reice *et al*., 1990; Armitage and Cannan, 1998; Wright *et al*., 2003).

Caddisflies, one of the largest groups of aquatic insects, occur in most types of freshwater habitats such as springs, streams and seepage areas, rivers, lakes, marshes and temporary pools (e.g., reviewed by Wiggins, 1996; Morse, 1999). There have been few previous reports on the seasonal changes in emerging adult caddisflies in the rivers of Japan, and any associated disturbances due to environmental impacts from anthropogenic activities have either been overlooked, or no relevant studies have been published. *Stenopsyche marmorata* is the largest caddisfly species in size in the middle reaches of the Chikuma. In order to assess the short-term impact of bank-protection works on the abundance pattern of *S. marmorata* from spring to early summer, we conducted an investigation on the capture of adults

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using light traps before and after construction work.

MATERIALS AND METHODS

Bank-protection project

The present investigation was performed in the middle reaches of the Chikuma River, which is located in the center of Honshu Island. It is Japan's longest river (length, ca. 367 km; drainage area, ca. 11,900 km^2), running through Nagano and Niigata Prefectures and flowing north into the Japan Sea (Fig. 1).

A major bank-protection project was undertaken from late October 2001 to late March 2002. During the project, to prevent river inflow into the area, the course of the river was excavated for 33,500 m^3, and narrowed with about 12,400 m^3 of banking. Then, the riverbed was lowered approximately 1,000 m^3, and around 1,380 concrete triblocks, weighing about 4 t each, were embedded therein. Next, blocks set in concrete were used for reinforcement to cover an area of about 3,000 m^3 (Fig. 1). Before the construction, the riverine habitat consisting of "unit structures" of a natural river system (i.e., scour pools, riffles, and runs) was generally well preserved. The riverbed was largely covered with cobbles and boulders about 10 to 50 cm in diameter. The width of the stream was about 25 m, and the average current velocity was 60-80 cm s^{-1}. The construction extensively altered the riverbed structure. Although the width of the stream was about the same as before the construction began, the riverbed was flattened out and became shallower with a relatively gentle flow of 40-60 cm s^{-1}. The riverbed became clogged with mud, causing increased stagnation in places where water had pooled and stopped flowing, resulting in an increase in the amount of attached algae covering the bed stones.

Collection of *S. marmorata* adults and larvae

The abundance of *S. marmorata* adult was monitored by daily catches using a light trap equipped with a 6-W black fluorescent lamp (Nozawa NH-5) set up at the floodplain in the middle reaches of the river in Ueda City from 19 April to 10 July (83 days) in 2001 (before construction) and was continued into 2002 (after construction). Insects that had entered the cage were killed with insecticide spray every morning at about 10 a.m. After being sorted out from the other insects, the numbers of male and female *S. marmorata* adults were counted separately in the laboratory. Environmental data (daily mean water temperature and daily mean water level) from the Ministry of Land, Infrastructure and Transport, the Hokuriku Regional Development Bureau, and Nagano Prefecture were used during the investigation periods.

S. marmorata larvae were collected using a

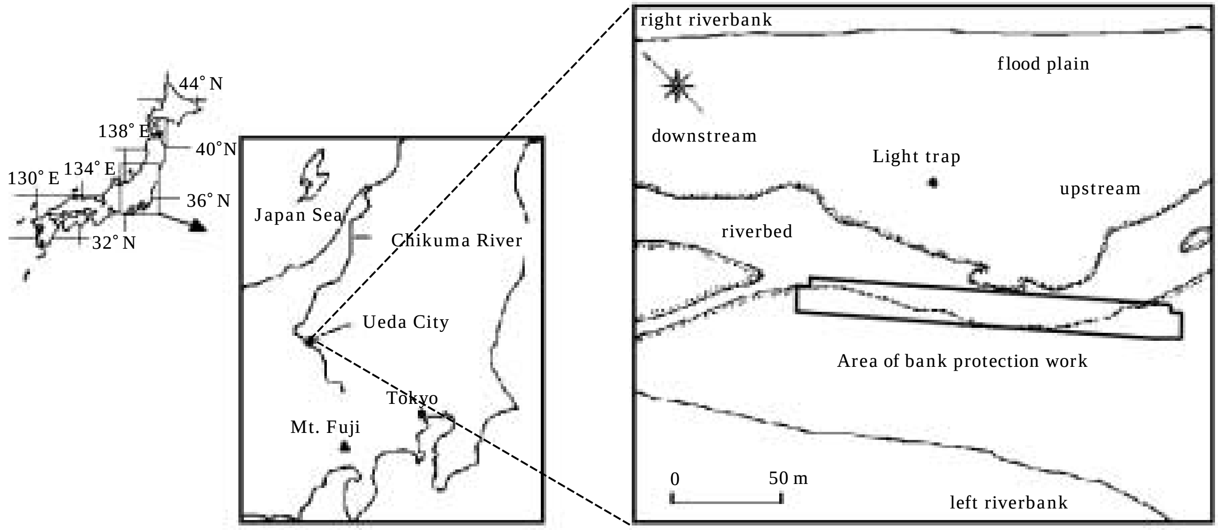

Fig. 1. Map of the Chikuma River, showing locations of the sampling sites and the bank-protection project area.

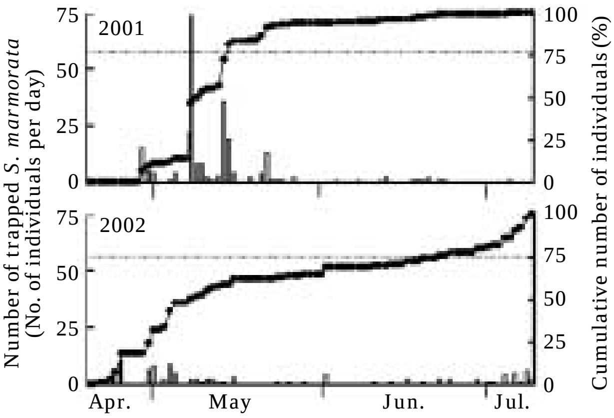

Fig. 2. Changes in daily captures of *Stenopsyche marmorata* adults by light traps and the cumulative number of individuals in 2001 and 2002.

surber sampler over an area of about 0.09 m^2 at two sites in the riffle, i.e., one upper site about 500 m above the bank−protection work area (control area, Station 1), and another site within the work area (Station 2). In a preliminary investigation, we confirmed that almost the same densities of *S. marmorata* larvae inhabited both stations. The collections were made once a month from April to June 2002 (except for Station 1 in April). The larvae of *S. marmorata* dislodged by manual disturbances in the square were trapped in an extended downstream net (opening mesh size: 450 μ). In the laboratory, the individual numbers of *S. marmorata* larvae were counted, and head widths were measured under a binocular microscope part of samples. Larval instars were determined based on the head width and morphological features described by Gose (1970).

RESULTS

Temporal changes in physical environmental conditions in 2001 and 2002

The daily mean water temperatures showed almost the same pattern during those two years. The temperature changes ranged between 10.2°C (April 26) to 23.0°C (July 5) in 2001, and 10.0°C (April 26) to 22.9°C (July 9) in 2002, averaging 16.5±3.3°C in 2001, and 16.5±3.1°C in 2002. The daily mean water levels also showed almost the same pattern during those years, averaging 0.02±0.13 m in 2001, and −0.11±0.14 m in 2002. Small floods in early July of 2002 (max. 1.67 m, July 11) had a major impact on caddisfly larvae. As a result, we had to finish our investigation on July 10. During the investigation periods, we established that the daily mean water temperatures and daily mean water levels followed almost identical patterns, with no significant differences between years.

Abundance of *S. marmorata* collected with a light trap

Using a light trap, many individuals of *S. marmorata* adults were collected before construction, but it was largely decreased in number after construction, i.e., a total of 222 adults during the investigation in 2001 vs 100 in 2002. In contrast, the male−to−female ratio remained almost the same during those years, i.e., 96.4% males in 2001, and 89.0% in 2002. Figure 2 shows changes in the daily capture of *S. marmorata* adults by light traps and in the cumulative numbers of individuals from spring to early summer of 2001 and 2002. Before construction, in 2001, *S. marmorata* adults were first collected in mid−April, and the daily number of adults caught reached a maximum in early May, i.e., 74 individuals per day in May 8. Then, although several peaks appeared from mid to late May, there were few peaks from early to mid−July. On the other hand, after construction in 2002, *S. marmorata* adults began to be collected in late April, and one peak (11 individuals per day) appeared in April 25. Thereafter, a few adults were collected until early July. The abundance pattern of the cumulative number of individuals of *S. marmorata* after the construction differed from that before construction. Before the construction, the cumulative number began to increase rapidly in early May, reaching more than 75% of individual numbers of *S. marmorata* trapped during the investigation periods on May 15 in 2001. On the other hand, after construction, the daily catch of adult numbers increased only slightly during the investigation periods, reaching more than 75% of the individual numbers on June 23 in 2002 (39 days later than that in 2001).

Pupal and Larval densities and age structure of *S. marmorata* in the Chikuma River

In April 2002, larval densities of *S. marmorata* were 0 individuals per m^2 at Station 2. In May, pupal and larval densities were 328 individuals

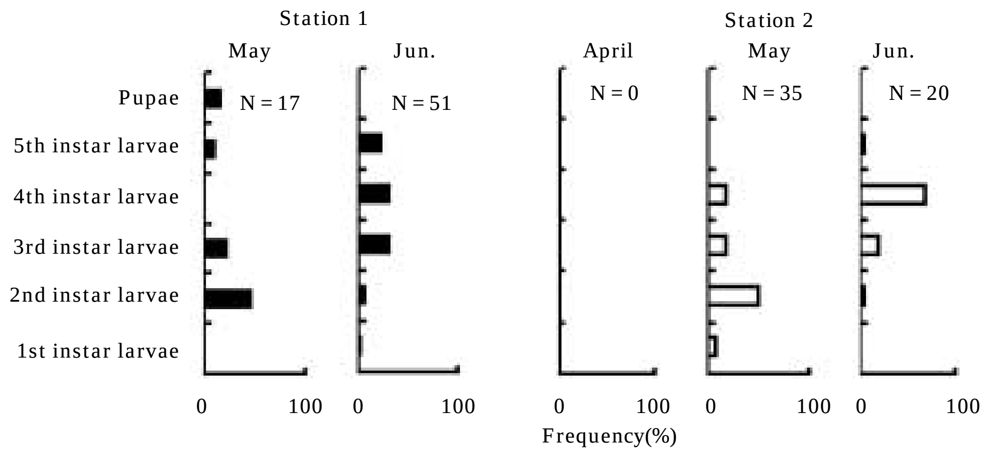

Fig. 3. Pupal and Larval densities and age structure of *Stenopsyche marmorata* at Station 1 (control area) and 2 (construction area) in the Chikuma River in 2002.

per m^2 at Station 1 (control area) and 400 individuals per m^2 at Station 2. In June, pupal and larval densities were 522 individuals per m^2 at Station 1 and were 400 individuals per m^2 at Station 2. Assuming the density at Station 1 to be 1.00, the ratio was 1.22 in May and 0.77 in June at Station 2. To clarify the process of recovery, the age structure of *S. marmorata* larvae was shown in Figure 3. In May, the frequency of 2^{nd} instar larvae (47.1%) was high and the 5^{th} instar larvae (11.8%) and pupae (17.6%) appeared at Station 1, while at Station 2 pupae and 5^{th} instar larvae did not appear. In June, the frequency of pupae decreased and frequency of 3^{rd}, 4^{th} and 5^{th} instar larvae increased at Station 1, while most larvae were 4^{th} instar (i.e., 70.0%) at Station 2. Under these circumstances, even though the investigation periods were the same, it was clear that the age structure of a *S. marmorata* larval population changed at Station 2.

DISCUSSION

In the present study, although the daily mean water temperatures and daily mean water levels exhibited almost the same pattern in 2001 and 2002, the pattern of daily captures of *S. marmorata* and its cumulative number of individuals differed, the capture in 2002 was 39 days later than that in 2001 (Fig. 2). Consequently, it was expected that almost all *S. marmorata* larvae would have disappeared (death and/or escape, etc.) from the construction area with its attendant anthropogenic activities after the construction was completed (0 individuals per m^2 at Station 2 in April, Fig. 3). After that, it was suggested that *S. marmorata* larvae would be supplied from outside area to the construction area. Nishimura (1984) reported that the younger larvae of *S. marmorata* were more likely to simply drift away. Thus, many *S. marmorata* young age larvae drift from upper region to the construction area. Drifting young age larvae could eventually grow and re-inhabit the construction area. Comparing with the control area, the age structure of a *S. marmorata* larval population changed in the construction area. The difference in adult emergence periods might be caused by a difference in the larval-age structure. The construction area, since the percentage of young age larvae was high and there were various instars larvae, their emergence periods would not have synchronized. Then, after construction, the daily catch of adult numbers increased only slightly during the investigation periods. This would, at least in part, explain the different patterns observed in the daily capture of adults and the cumulative number of individuals recorded.

In conclusion, it was suggested that bank-protection projects significantly impacted the abundance pattern of adult caddisflies populations in river ecosystem under this study. The coming challenge is to undertake a more detailed study of the same kind on a riparian works project greater in scale over a longer period on another river system so as to provide more data in order to determine more accurately the impact of such projects on aquatic life.

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REFERENCES

Armitage, P.D. and C.E. Cannan. 1998. Nested multi −scale surveys in lotic system−tool for management. In: Bretschko, G., Helesic, J. (eds.), *Advances in River Bottom Ecology*, pp. 293−314. Backhuys Publishers, Leiden.

Brooks, S.S. and A.J. Boulton. 1991. Recolonization dynamics of benthic macroinvertebrates after artificial and natural disturbances in an Australian temporary system. *Australian Journal of Marin and Freshwater Research* **42**: 295−308.

Downes, B.J., L.A. Barmuta, P.G. Fairweather, D.P. Faith, M.J. Keough, P.S. Lake, B.D. Mapstone and G.P. Quinn. 2002. Monitoring ecological impacts: concepts and practice in flowing waters. P.434, Cambridge University Press, Cambridge.

Gose, K. 1970. Life history and instar analysis of *Stenopsyche griseipennis* (Trichoptera). *Jpn. J. Limnol.* **31**: 96−106.

Hurlbert, S.J. 1984. Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* **54**: 187−211.

Morse, J.C. (editor) 1999. Trichoptera World Checklist. http://entweb.clemson.edu/database/trichopt/index.htm, effective 22 May 1999.

Nishimura, N. 1984. Ecological studies on the net−spinning caddisfly, *Stenopsyche marmorata* Navas (Trichoptera: Stenopsychidae), 6. Larval and pupal density in the Maruyama River, central Japan, with special reference to floods and after−flood recovery processes. *Physiol. Ecol. Japan.* **21**:1−34.

Reice, S.R., R.C. Wissmar and R.J. Naiman. 1990. Disturbance regimes, resilience, and recovery of animal communities and habitats in lotic ecosystem. *Environmental Momt.* **14**: 647−659.

Strwart−Oaten, A., W.M. Murdoch, K.R., Parker. 1986. Environmental impact assessment: ‘pseudoreplication’ in time? *Ecology* **67**: 929−940.

Underwood, A.J. 1992. Beyond BACI: the detection of environmental impact on populations in the real, but variable world. *Journal of Experimental Marin Biology and Ecology* **161**: 145−178.

Underwood, A.J. 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. *Ecological Applications* **4**: 3−15.

Wigging, G.B. 1996. Trichoptera families. *In*: Merritt, R.W. and Cummins, K.W. (editors), *An introduction to the aquatic insects of Noth America*−3rd edition. 309−386. Kendall−Hunt Publishing Company, USA.

Wright, J.F., R.T. Clarke, J.M. Gunn, J.M. Winder, N.T. Kneebone and J. Davy−Bowker. 2003. Response of the flora and macroinvertebrate fauna of a chalk stream site to changes in management. *Freshwater Biology* **48**: 894−911.

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<국문적요>

Chikuma 강 중류 수역에서 하안 보호 공사가 *Stenopsyche marmorata* (Trichoptera)에 미치는 영향(Central Japan)

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동계에 Chikuma 강 중류 수역에서 대규모 하안 보호 공사가 시행된 이후로 강의 하상 구조에 급격한 변화가 나타났다. 본 연구는 연속하는 춘계-하계 기간 동안 날도래목 곤충의 일종인 *Stenopsyche marmorata*의 밀도 유형에 대한 하안 보호 공사의 영향을 평가하기 위해 수행되었다. Light trap을 이용하여 날도래 성충을 포획하여 분석한 결과에 의하면, *S. marmorata*에 대한 일일 포획의 양상과 포획 개체의 누적 밀도는 공사 전후에 상이하게 나타났다. 즉, 공사 후의 조사 기간 동안 일일 포획 성충의 밀도는 약간 증가하였다. 이 결과는 공사 지역에서 *S. marmorata* 유충 개체군의 연령 구조가 바뀌었고, 하안 보호 공사가 Chikuma 강 생태계에 서식하는 날도래 성충의 밀도 패턴에 영향을 미쳤음을 시사한다.